Micro-albuminuria in obese subjects: relationship among body fat distribution, blood pressure and left ventricular structure and function

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Objective To evaluate the relationships among micro-albuminuria, blood pressure and measurements of left ventricular structure and function in centrally and peripherally obese subjects compared with members of a lean control group.

Methods Centrally obese subjects were subdivided according to whether they had levels of micro-albuminuria higher than 30 mg/24 h (micro-albuminuric group) or lower than or equal to 30 mg/24 h (normo-albuminuric group). For all the subjects we measured heart rate, casual mean blood pressure (MBP), 24 h MBP, total cholesterol level, high-density lipoprotein cholesterol, lipoprotein (a) level, fasting immunoreactive insulin level, plasma renin activity, plasma aldosterone level and micro-albuminuria (UAE) by current methods. Left ventricular mass indexed for body height, left ventricular diastolic and systolic diameters, interventricular septal thickness and left ventricular ejection fraction were measured by echocardiography. Peak filling rate was also calculated by radionuclide study. Family history of cardiovascular disease was evaluated for all the obese subjects.

Results Lipoprotein (a) level, total cholesterol level, 24 h MBP and interventricular septal thickness were significantly ($P < 0.05$) greater for micro-albuminuric than they were for normo-albuminuric centrally obese subjects, whereas high-density lipoprotein cholesterol level and left ventricular ejection fraction were significantly ($P < 0.05$) lower. In addition, UAE levels of centrally obese subjects were significantly ($P < 0.05$) higher than those of peripherally obese subjects. UAE of all the centrally obese subjects was correlated directly to lipoprotein (a) level ($r = 0.33$, $P < 0.009$), 24 h MBP ($r = 0.41$, $P < 0.002$), interventricular septal thickness ($r = 0.36$, $P < 0.005$) and family history of cardiovascular disease ($r = 0.33$, $P < 0.007$). Multiple regression analysis indicated that UAE was independently related to 24 h MBP and family history of cardiovascular disease.

Conclusion Our data indicated that measurement of micro-albuminuria is useful for evaluating cardiovascular risk profiles of obese subjects with a central fat distribution. *Blood Press Monit* 3:233–240 © 1998 Lippincott Williams & Wilkins.

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Keywords: central obesity, micro-albuminuria, blood pressure, left ventricular function and structure

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Introduction

Obesity is considered an important risk factor for cardiovascular disease, especially when it is of central type [1–4]. For young obese subjects with central fat distribution we have recently found some abnormalities indicating that these subjects could have a higher risk of cardiovascular disease than do lean subjects. They included an atherogenetic lipid profile [higher than normal plasma apolipoprotein B and lipoprotein(a) levels and lower than normal plasma high-density lipoprotein (HDL) cholesterol levels], a pro-thrombotic and hypo-fibrinolytic pattern (higher than normal levels of factor VII, fibrinogen, plasminogen activator inhibitor and tissue plasminogen activator in plasma) [5] and silent left ventricular dysfunction [6–9].

On the other hand, micro-albuminuria, defined as a rate of urinary excretion of albumin (UAE) of 30–200 mg/24 h [10,11], has been reported for some subsets of hypertensive patients and it has been considered an early marker of renal damage [12]. In addition, greater than normal UAE levels have recently been reported for normotensive subjects with a genetic risk of hypertension [13]. The presence of micro-albuminuria is thought to be associated with a greater than normal incidence of cardiovascular morbidity and mortality, especially among hypertensive patients [14,15]. The reasons for this association have not been established.

In view of this, our previous data indicated that there was a greater prevalence of micro-albuminuria among obese than there was among lean subjects [6] and this has been related to the effects of central obesity on renal haemodynamics [16]. Nevertheless, little is known about the relationship between UAE and cardiovascular risk factors of obese subjects. In an attempt to obtain more information on the factors related to micro-albuminuria in obesity, the objective of the present study was to analyse lipid levels, casual and ambulatory 24 h blood pressures and left ventricular function and structure in lean and obese subjects both with central and with peripheral body fat distributions.

Our final goal was to evaluate whether micro-albuminuria can impair cardiovascular risk profile of centrally obese subjects.

Subjects and methods

Subjects

We studied 92 obese subjects (64 with central obesity and 28 with peripheral obesity) and 20 lean controls aged less than 40 years. Obese subjects were consecutively recruited in the obesity centre of the Internal Medicine Department at the University of Palermo, Italy.

The subjects were defined obese according to sex-specific 85th percentile of body mass index (BMI) values reported at the Italian Consensus Conference on obesity [17]. Accordingly, men with BMI > 30.5 kg/m^2 and women with BMI > 27.3 kg/m^2 were considered obese whereas men with BMI < 25 kg/m^2 and women with BMI < 24.7 kg/m^2 were considered lean. Body fat distribution was evaluated by measuring waist : hip girth ratio (WHR) of the standing subject, as previously reported [5–8]. Central obesity was defined according to the sex-specific 85th percentile of WHR values [17]. Men with WHR $\geq$ 0.92 and women with WHR $\geq$ 0.81 were considered centrally obese, whereas women with WHR < 0.81 and men with WHR < 0.92 were considered peripherally obese.

Criteria for exclusion of subjects from our study were smoking habits, hypertension (arterial pressure was recorded with an appropriately large cuff for obese subjects), cardiovascular disease (defined as myocardial infarction, chest pain, heart blockage, valvular disease and heart failure), renal diseases, insulin-dependent and insulin-independent diabetes mellitus, familial hypercholesterolaemia, electrolyte imbalances, alcoholism and psychiatric problems. Lean and obese subjects were matched with regard to age, sex and height (Table 1).

The study was approved by the ethics committee of Palermo University and each patient gave their informed consent to participate in our study after they had been given a detailed description of the study procedure. Preliminary investigation included measurements of levels of blood and urinary electrolytes, rate of clearance of creatinine, fasting blood sugar level and oral glucose-tolerance and liver function tests. In addition, after the selection phase, serum total and HDL cholesterol levels, lipoprotein(a) level, fasting insulin level, plasma renin activity and UAE were measured. Only for two lean subjects and four peripherally obese subjects were UAE values higher than 30 mg/24 h and they were not considered for further allocation to subgroups. Accordingly, centrally obese subjects were subdivided into two groups on the basis of their UAE levels ($\leq$ 30 mg/24 h for normo-albuminuric subjects; > 30 mg/24 h for micro-albuminuric subjects).

Normo-albuminuric subjects comprised 17 women and 18 men, aged 23–39 years (mean 33 ± 4) with mean BMI value 33.6 ± 4 kg/m^2 and mean WHR value 0.94 ± 0.05 (men 1.02 ± 0.04, women 0.92 ± 0.04). Micro-albuminuric subjects comprised 15 women and 14 men, aged 20–38 years (mean 34 ± 4) with mean BMI value 33.9 ± 4 kg/m^2 and mean WHR value 0.96 ± 0.07 (men 1.02 ± 0.03, women 0.92 ± 0.06).

These two groups were comparable with regard to age, height, BMI and WHR (Table 2). Family history of cardiovascular disease (CVD) was investigated for subjects in both obese groups. Data on the presence or absence of CVD in parents and siblings aged $\leq$ 65 years were obtained as previously described [18].

To avoid bias, the family history information was in all cases collected by physicians who were ignorant of the purpose and the results of the study. Information on blood pressure, use of antihypertensive or other specific drugs and cardiovascular complications in parents and siblings was obtained from the family physician and, for parents or siblings attending our clinic as regular outpatients, also from the clinical records. The historical information was further validated by direct questioning of all parents. Any subject who had one parent with myocardial infarction or angina, cerebrovascular disease or events was considered to have a positive family history of CVD whereas a negative family history was assumed when neither parent and none of the siblings of the obese subjects had suffered from these diseases.

Methods

For all the obese subjects the following measurements were performed.

Casual and 24 h blood pressures

Casual systolic blood pressure (SBPc) and casual diastolic blood pressure (DBPc) were measured in triplicate by using a mercury sphygmomanometer with the subjects supine. DBPc refers to Korotkoff phase V. Casual mean blood pressure (MBPc) was calculated from the sum DBPc plus one-third of the arterial pulse pressure.

Table 1 **Details of lean subjects, centrally obese subjects and peripherally obese subjects**

		Obesity	
	Lean (n = 20)	Central (n = 64)	Peripheral (n = 28)
Sex (female/male)	10/10	32/32	14/14
Age (years)	32 ± 7	33 ± 4	34 ± 2
Height (cm)	160 ± 9	159 ± 8	160 ± 7
BMI (kg/m^2)	22 ± 2	34 ± 4*	34 ± 4*
WHR (%)	0.87 ± 0.04	0.95 ± 0.06*†	0.84 ± 0.05
UAE (mg/24 h)	19 ± 5	40 ± 8*†	20 ± 12
Total serum cholesterol (mg/dl)	180 ± 1	198 ± 26*†	188 ± 15
HDL cholesterol (mg/dl)	39 ± 2	36 ± 4*	37 ± 4
IRI (pmol/l)	9 ± 2	17 ± 8*†	13 ± 4*
Lipoprotein(a) (mg/dl)	7 ± 9	27 ± 17*†	18 ± 10*
Minimum	2.2	2	3
Maximum	70	92	88
Median	5	14	10
PRA (ng/ml per h)	2.1 ± 0.5	2.7 ± 0.9*†	2.3 ± 0.8
Plasma aldosterone (pg/ml)	230 ± 52	235 ± 60	230 ± 50

Values are expressed as means ± SD. BMI, body mass index; WHR, waist : hip ratio; UAE, urinary excretion of albumin; HDL, high density lipoprotein; IRI, immunoreactive fasting serum insulin; PRA, plasma renin activity. Differences among lipoprotein(a) levels for the groups were assessed by Whitney's *U* test. *$P < 0.05$, versus lean subjects; †$P < 0.05$, versus peripherally obese subjects.

Table 2 **Casual and 24 h ambulatory blood pressures and measurements of left ventricular function and structure in lean and obese subjects**

		Obesity	
	Lean (n = 20)	Central (n = 64)	Peripheral (n = 28)
Heart rate (beats/min)	72 ± 4	74 ± 5	74 ± 4
MBP (mmHg)	93 ± 7	95 ± 6*	94 ± 6*
24 h MBP (mmHg)	83 ± 4	87 ± 4*†	82 ± 4
Diurnal MBP (mmHg)	86 ± 3	90 ± 4*†	85 ± 4
Nocturnal MBP (mmHg)	80 ± 5	84 ± 3*†	79 ± 3
LVM/*H* (g/m)	80 ± 25	105 ± 21*	103 ± 15*
LVDD (mm)	45 ± 7	51 ± 4*†	48 ± 4*
LVSD (mm)	30 ± 5	34 ± 6*†	30 ± 5
IVST (mm)	8 ± 1	9 ± 1*†	8 ± 2
LVEF (%)	65 ± 4	61 ± 3*†	63 ± 3*
PFR (cm^3/s)	3.5 ± 0.8	2.9 ± 0.5*	3.1 ± 0.6*

Values are expressed as means ± SD. MBP, mean blood pressure; LVM/*H*, left ventricular mass/height; LVDD, left ventricular diastolic diameter; LVSD, left ventricular systolic diameter; IVST, interventricular septum thickness; LVEF, left ventricular ejection fraction; PFR, peak filling rate. *$P < 0.05$, versus lean subjects; †$P < 0.05$, versus peripherally obese subjects.

Arterial pressure was measured with an appropriately wide cuff for all the subjects [5–8]. Heart rate was evaluated from an electrocardiographic tracing.

Ambulatory blood pressure was recorded by using the portable fully automatic Takeda TM2420 system (A&D Co. Ltd, Tokyo, Japan) connected through the serial interface (RS232) to an IBM personal system 2 computer (IBM, Milan, Italy), which in our laboratory exhibited a correlation of r = 0.96 both to SBPc and to DBPc [19]. An appropriately large cuff was available to allow precise 24 h blood pressure readings for obese subjects. The reading, editing and summary analysis of data provided by the unit was performed by dedicated software. The unit was set to take readings automatically every 20 min throughout the 24 h period. This approach has been tolerated well by all the patients who were studied. Twenty-four-hour mean SBP, DBP and MBP both diurnal and nocturnal were calculated.

Criteria for deleting individual blood pressure readings included a pulse pressure < 12 mmHg, inconsistent increases and decreases in SBP and in DBP of > 30 mmHg relative to previous or subsequent readings.

Recordings were analysed in this study only if at least 80% of the maximal number of 72 readings during the 24 h period passed the deletion criteria. Journals of activity, symptoms and emotions were carefully kept by the subjects for aid in the editing process.

Echocardiographic measurements

Left ventricular mass (LVM), LVM indexed for body height (LVM/*H*), left ventricular diastolic internal dimension (LVDD), left ventricular systolic internal dimension (LVSD) and interventricular septal thickness (IVST) were calculated from echocardiographic findings, as previously reported [19,20].

Two-dimensional and M-mode echocardiographic examination was performed by using an Esaote Biomedica computer-aided ultrasound system (Consalop SpA, Florence, Italy) equipped with 2.5 and 3.5 MHz phased array transducers and a standard video system.

Ejection fraction from left ventricular end-diastolic and end-systolic volumes was measured from the apical four-chamber view, using the ellipsoidal single-plane algorithm [21]. Mean ejection fraction was automatically calculated by the echocardiographic processing system. In our laboratory the ejection fraction calculated over five consecutive beats permitted optimal reproducibility and accuracy [20].

Peak filling rate and time to peak filling rate

Peak filling rate (PFR) and time to PFR (t-PFR) were measured by radionuclide angiocardiography, using the blood-pool-gated method according to Bonow *et al.* [22]. A computerized large-field scintillation camera (Starcam 400; General Electric, Chicago, Illinois, USA) with a high-resolution 1.5 inch parallel hole collimator was used.

This method has been validated in our laboratory, in particular for obese subjects [8,18]. End-diastolic volume (EDV) and PFR (namely, EDV/time of filling (s)) were calculated using radionuclide angiocardiography.

Analytical methods

Venous blood samples were drawn after subjects had fasted overnight for determination of fasting blood sugar level, total and HDL cholesterol levels, immunoreactive insulin (IRI) level, plasma renin activity (PRA), plasma aldosterone level and serum lipoprotein(a) level. All blood samples were kept on ice until the time of the assay. In addition, three consecutive 24 h urine collections were used to determine the presence of microalbuminuria.

Fasting blood sugar level was measured in triplicate with a Technicon AA II auto-analyser by the glucose oxidase technique. Serum total and plasma HDL cholesterol levels were measured by enzymatic methods (Böhringer-Mannheim, Mannheim, Germany).

Insulin

Immunoreactive insulin levels were detected by the radioimmunoassay double-antibody method using a commercial kit (Sorin, Saluggia, Italy). Intra-assay variation was 7.5% and inter-assay variation was 8%. Sensitivity for detection of insulin was 2.5 μU/ml.

PRA and plasma aldosterone level

PRA and plasma aldosterone level were measured by the radioimmunoassay, using a commercial kit (Sorin, Saluggia, Italy). Intra-assay variations were 5% for PRA and 9.5% for plasma aldosterone level whereas inter-assay variations were 7% for PRA and 11.2% for plasma aldosterone level. Sensitivities were 0.12 ng/ml for PRA and 15 pg/ml for plasma aldosterone level [23].

Lipoprotein(a)

Serum levels of lipoprotein (a) were analysed by a solid-phase two-site immunoradiometric assay with antisera standards and control materials from Pharmacia Diagnostic AB (Uppsala, Sweden). It is based on the direct sandwich technique in which two monoclonal antibodies are directed against separate antigenic determinants on the apolipoprotein (a) molecule. Cross reactivity with plasminogen and apolipoprotein B is absent up to concentrations of 8.5 g/l for plasminogen and 7.0 g/l for apolipoprotein B in this assay. The inter-assay and intra-assay variations were < 9% and < 5%, respectively. Sensitivity for detection of lipoprotein (a) was 1.4 mg/l [24]. Because of its wide variance, ranges and medians are additionally reported for lipoprotein(a) levels.

UAE

To eliminate the intra-individual day-to-day variability of UAE, three consecutive 24 h urine collections were used. In addition, to assess the completeness of a 24 h urine collection, measurements of urinary rate of clearance of creatinine were evaluated. Micro-albuminuria was measured through a double-antibody radioimmunoassay method, using a commercial kit (Sclavo, Siena, Italy). Intra-assay coefficient of variation was 5.1% , inter-assay coefficient of variation was 6.3% and sensitivity limit of the assay was 0.1 mg/l.

Statistical analysis

Comparisons between lean and obese subjects were analysed by one-way analysis of variance and post-hoc Newman–Keuls test. Comparisons between normoalbuminuric and micro-albuminuric obese subjects were analysed by Student's unpaired t test. Since an asymmetry of lipoprotein(a) level data distribution was evident (high skewness), the differences among lipoprotein(a) levels for the groups were analysed by a non-parametric test (i.e. Mann–Whitney *U* test).

The difference between percentages of subjects with positive family histories of CAD in the two obese groups was analysed by χ test. Linear and multiple regression analyses were performed to calculate the coefficients of correlations between UAE and all the measurements

Table 3 **Details of normo-albuminuric and micro-albuminuric centrally obese subjects**

	Normo-albuminuric (n = 35)	Micro-albuminuric (n = 29)	Significance
Sex (female/male)	17/18	15/14	
Age (years)	33 ± 4	34 ± 4	NS
Height (cm)	157 ± 8	161 ± 9	NS
BMI (kg/m²)	34 ± 4	34 ± 4	NS
WHR (%)	0.94 ± 0.05	0.96 ± 0.07	NS
UAE (mg/24 h)	17 ± 6.3	67 ± 10	$P < 0.001$
PFH	15 (52.5)	20 (69)	NS[a]
Total serum cholesterol (mg/dl)	188 ± 25	208 ± 27	$P < 0.004$
HDL cholesterol (mg/dl)	40 ± 4	32 ± 3	$P < 0.001$
IRI (pmol/l)	16 ± 7	18 ± 9	NS
Lipoprotein(a) (mg/dl)	18 ± 16	34 ± 19	$P < 0.001$[b]
Minimum	2	2	
Maximum	80	102	
Median	11	16	
PRA (ng/ml per h)	2.5 ± 1	2.8 ± 0.9	NS
Plasma aldosterone (pg/ml)	234 ± 63	237 ± 76	NS

Values are expressed as means ± SD except for positive family history of cardiovascular disease (PFH), which is expressed as numbers (percentages). BMI, body mass index; WHR, waist : hip ratio; UAE, urinary excretion of albumin; HDL, high density lipoprotein; IRI, immunoreactive fasting serum insulin; PRA, plasma renin activity.
[a]z test. [b]Mann–Whitney *U* test.

Table 4 **Casual and 24 h ambulatory blood pressures and measurements of left ventricular function and structure in normo-albuminuric and micro-albuminuric centrally obese subjects**

	Normo-albuminuric (n = 35)	Micro-albuminuric (n = 29)	Significance
Heart rate (beats/min)	74 ± 5	74.5 ± 4	NS
MBP (mmHg)	94 ± 5	96 ± 7	NS
24 h MBP (mmHg)	85 ± 3	88 ± 6	$P < 0.004$
Diurnal MBP (mmHg)	88 ± 4	90 ± 5	NS
Nocturnal MBP (mmHg)	82 ± 3	85 ± 3	NS
LVM/*H* (g/m)	97 ± 19	105 ± 23	NS
LVDD (mm)	50 ± 4	52 ± 4	NS
LVSD (mm)	33 ± 5	35 ± 8	NS
IVST (mm)	8 ± 2	10 ± 1	$P < 0.001$
LVEF (%)	62 ± 3	60 ± 4	$P < 0.05$
PFR (cm³/s)	3.0 ± 0.5	2.8 ± 0.5	NS

Values are expressed as means ± SD. MBP, mean blood pressure; LVM/*H*, left ventricular mass/height; LVDD, left ventricular diastolic diameter; LVSD, left ventricular systolic diameter; IVST, interventricular septum thickness; LVEF, left ventricular ejection fraction; PFR, peak filling rate.

studied. Relationship between micro-albuminuria and family history of CVD was analysed by general factorial analysis of variance.

In the multiple regression analysis 24 h MBP and family history of CVD were dependent variables and UAE, IVST, LVM/*H*, IRI level and PRA were independent variables. All the data are presented as means ± SD. P value < 0.05 was considered statistically significant.

Results

Characteristics of lean and obese subjects

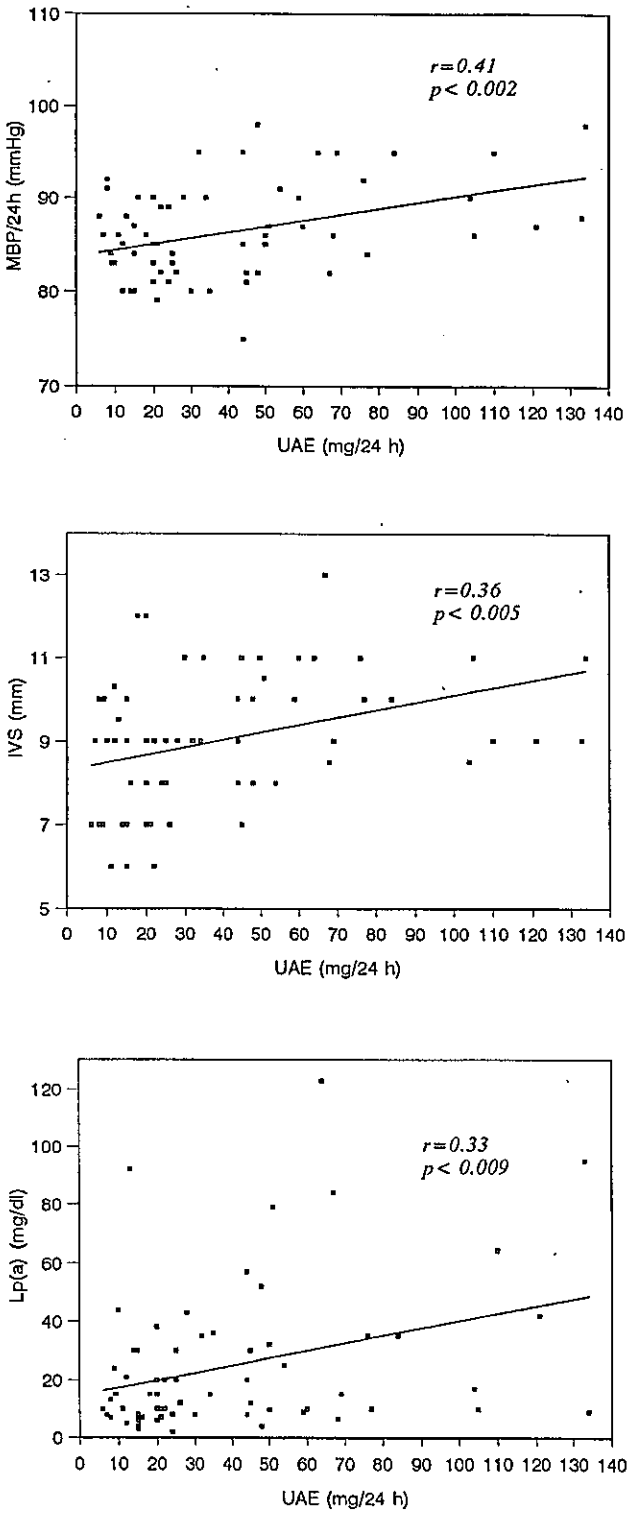
Lean and obese subjects were comparable with regard to sex, age and height. In addition, peripherally and centrally obese subjects were comparable with regard to BMI values (Table 1).

UAE, IRI level, lipoprotein(a) level, PRA, 24 h MBP, LVM/*H*, LVDD, IVST, total cholesterol level and LVSD were significantly ($P < 0.05$) higher for centrally obese subjects than they were for lean subjects, whereas LVEF, PFR and HDL cholesterol level were significantly ($P < 0.05$) lower. In addition, IRI level, lipoprotein(a) level, MBP, LVM/*H* and LVDD for peripherally obese subjects were significantly ($P < 0.05$) higher than they were for lean subjects, whereas LVEF and PFR were significantly ($P < 0.05$) lower (Tables 1, 3). Moreover, UAE, cholesterol, IRI level, lipoprotein(a) level, PRA, 24 h MBP, LVDD, LVSD and IVST were significantly ($P < 0.05$) higher for centrally obese subjects than they were for peripherally obese subjects, whereas LVEF was significantly ($P < 0.05$) lower (Tables 1, 3).

Normo-albuminuric versus micro-albuminuric centrally obese subjects

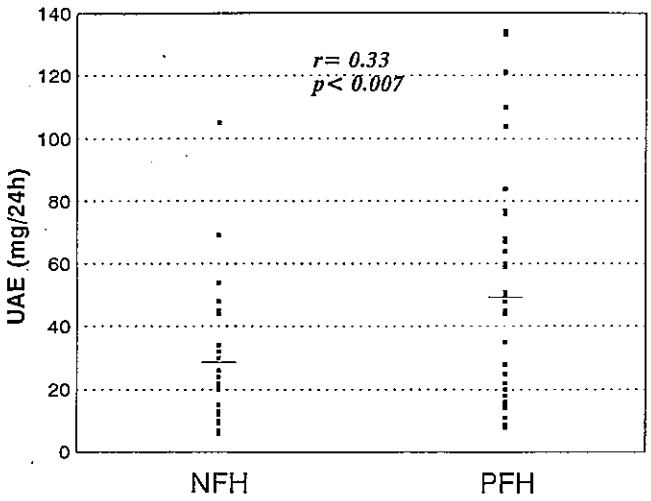
Normo-albuminuric and micro-albuminuric obese subjects were comparable with regard to sex, age, height, BMI and WHR (Table 2). Levels of lipoprotein(a) ($P <$

Fig. 1



Correlations between micro-albuminuria (UAE) and 24 h mean blood pressure (MBP/24h), interventricular septal thickness (IVS) and lipoprotein (a) level [Lp(a)] in central obese subjects.

Fig. 2



Relationship between micro-albuminuria (UAE) and family history of cardiovascular disease for centrally obese subjects. NFH, negative family history; PFH, positive family history.

0.001) and total cholesterol ($P < 0.004$) values were significantly higher and HDL cholesterol levels were significantly ($P < 0.001$) lower in micro-albuminuric than they were in normo-albuminuric obese subjects. IRI level, PRA and plasma aldosterone level in members of the two obese groups did not differ significantly (Table 2). Moreover, a greater but not significant percentage of micro-albuminuric than of normo-albuminuric obese subjects (69 versus 52.5%) had a positive family history of CVD.

Blood pressure, left ventricular function and structure

Twenty-four-hour MBP ($P < 0.004$) and IVST ($P < 0.001$) were significantly greater and LVEF ($P < 0.05$) were significantly lower for micro-albuminuric than they were for normo-albuminuric obese subjects. In addition, in both groups we found no subject without nocturnal dipping of blood pressure (Table 4).

Correlations

UAE of all centrally obese subjects was correlated directly to lipoprotein(a) level ($r = 0.33$, $P < 0.009$), 24 h MBP ($r = 0.41$, $P < 0.002$) and IVST ($r = 0.36$, $P < 0.005$; (Fig. 1). Factorial analysis of variance revealed a positive relationship between UAE and family history of CVD ($r = 0.33$, $P < 0.007$; Fig. 2).

Multiple regression analysis indicated that UAE was independently related to 24 h MBP and family history of cardiovascular disease even when IRI level, PRA, LVM/*H* and IVST were included in the analysis.

Discussion

The present results indicate that there is a clear association between micro-albuminuria and major cardiovascular

risk factors for normotensive centrally obese subjects. In fact, micro-albuminuric centrally obese subjects were characterized by higher levels of total cholesterol, lipoprotein (a), 24 h MBP and IVST and by lower levels of HDL cholesterol and left ventricular ejection fraction than those detectable for comparable normo-albuminuric obese subjects. Moreover, a higher percentage of micro-albuminuric (69%) than of normo-albuminuric centrally obese subjects (52.5%) had a positive family history of CVD.

To the best of our knowledge, the present study is the first to consider the associations between micro-albuminuria and other cardiovascular risk factors for a sample of centrally obese subjects. Because we wanted to focus on patients with central obesity and examined the roles of body fat distribution and other cardiovascular risk factors, we selected a population of subjects aged < 40 years to avoid inclusion of subjects with detectable vascular damage.

Despite micro-albuminuria having been reported to be associated with greater than normal cardiovascular and total mortality [12,14,15] and even though the study of micro-albuminuria as a prognostic marker of cardiovascular and renal outcomes in hypertension has increased [25,26], few data on the relationships among central obesity, micro-albuminuria and CVD are available [26]. Ribstein *et al.* [27] have recently reported that BMI might be associated with micro-albuminuria for obese normotensives and for hypertensives.

Conversely, it is well known that some abnormalities frequently detectable in centrally obese subjects (i.e. insulin resistance, greater than normal levels of low-density lipoprotein cholesterol and apolipoprotein B and lower than normal HDL cholesterol levels) may be associated with micro-albuminuria for normotensive and hypertensive subjects [5,28,29]. This fact might also explain why the prevalence of micro-albuminuric subjects among centrally obese subjects is higher than that among peripherally obese subjects for those we have studied. In addition, an impairment of renal haemodynamics recently demonstrated to occur in centrally obese subjects might be responsible for greater than normal UAE of these subjects [16]. Moreover, Bigazzi *et al.* [30] have recently reported finding a greater UAE for salt-sensitive than for salt-resistant hypertensive patients, suggesting that micro-albuminuria is an expression of an unfavourable renal haemodynamic situation that could in the long run result in renal damage. Although in the present study we have not determined salt sensitivity of blood pressure, it is well known that salt-level-regulating hormonal mechanisms in centrally obese subjects are altered early on [23,31,32]. This might induce speculation that micro-albuminuria has to be considered a detectable marker of hypertension in centrally obese subjects. This hypothesis was further supported by the positive correlation between micro-albuminuria and 24 h MBP and by multiple regression analysis indicating that micro-albuminuria and 24 h MBP were independently related to one another for these subjects. This is consistent with recent data suggesting that micro-albuminuria is detectable for normotensive subjects with a genetic risk for hypertension [13,33].

In the present study micro-albuminuria was also related to a family history of CVD, lipoprotein(a) level and IVST. These data may be interesting if one considers the roles of lipoprotein(a) levels and family history of CVD in predicting cardiac events [34,35] and of 24 h MBP and IVST in predicting cardiac damage [36,37].

The mechanisms responsible for this association are still unknown but, according to recent data published by Pedrinelli *et al.* [38], they could be related to a systemic endothelial dysfunction, leading to greater than normal exposure to cardiovascular risk. On the other hand, our preliminary but unpublished data indicate that abnormalities in endothelial function in young normotensive centrally obese subjects are detectable early on.

In addition, micro-albuminuria detectable for centrally obese subjects was associated with impairment of left ventricular structure and function. In fact, IVST were greater and ejection fractions were lower for micro-albuminuric than they were for normo-albuminuric subjects among those we have studied. This further supports our opinion that an early involvement of left ventricular structure and function could be detectable for obese subjects and related to their body fat distribution [5,6]. Accordingly, some results [39,40] demonstrated that there is a positive relationship between IVST and WHR for normotensive and hypertensive obese subjects.

In conclusion, we found a strong relationship between micro-albuminuria and 24 hours blood pressure in centrally obese subjects. It was associated with significant changes in left ventricular structure and function. This finding might help to explain the higher susceptibility of obese subjects with central fat distributions to developing hypertension and CVD. Accordingly, detection of micro-albuminuria for centrally obese subjects could be considered a suitable measure for evaluating obese subjects as candidates for CVD.

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